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THE VARIATIONS OF GLACIERS. XVI[1]

HARRY FIELDING REID
Johns Hopkins University

The following is a summary of the *Fifteenth Annual Report* of the International Committee on Glaciers.[2]

REPORT OF GLACIERS FOR 1909

Swiss Alps.—Of the ninety glaciers measured in 1909, only two have been advancing for three successive years, the Scex-rouge and the lower Grindelwald Glacier; the latter has advanced 59 meters in two years. Nine other glaciers have advanced slightly during the last year but it is not certain that they are in a stage of advance. A general retreat is dominant in the Swiss Alps.[3]

Eastern Alps.—Thirty-nine glaciers were measured, and the retreat is general, although in many cases it is slow. The Langtaler Glacier and the Grosselendkees seem to be stationary, and the Mitterkarferner has made a small advance.[4]

Italian Alps.—The retreat, which has been general for some years, seems to be continuing without change.[5]

French Alps.—Observations on the snow-fall and the variation in the length of glaciers have continued, and maps of some glaciers are being made on a scale of 1 : 10,000. In the Mont Blanc range the retreat is nearly general, though slight; the Glacier des Bossons has advanced a little more than one meter. The ends of the glaciers have in general diminished in thickness with a corresponding diminution in the velocity of flow. In the Tarentaise and Maurienne the retreat is also general, but feeble. In the Dauphiné we find that the snow-fall has been distinctly heavier since 1906 with the result that the glaciers on the northern side of the Pelvoux massif have grown thicker and are beginning to advance; and the whole appearance of the reservoirs indicates that the advance in this region will become general. In the southern part of the same massif, although the increase in the snow-fall is also marked, the retreat of the glaciers continues. In the Pyrenees the snow-fall has been heavy since 1906 and the small glaciers show a marked tendency to increase in size.[1]

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[1] The earlier reports appeared in the *Journal of Geology*, Vols. III–XIX.

[2] *Zeitschrift für Gletscherkunde* (1911), V, 177–202.

[3] Report of Professor Forel and M. Muret.

[4] Report of Professor Brückner.

[5] Report of Professor Marinelli.

Swedish Alps.—A number of glaciers have been measured and the changes resulting during a variable number of years up to 1909 indicate a slight increase in general, though a few of the glaciers are apparently stationary and one or two slightly retreating.[2]

Norwegian Alps.—The difference in the behavior of the glaciers of Jotunheim, in the interior of Norway, and those of Folgefon and Jostedalsbrä, near the coast, which was commented on in the last report, continues. The glaciers near the coast are generally advancing, whereas those in the interior are generally retreating.[3]

Russia.—The greater part of the glaciers observed in the Caucasus between 1899 and 1907 have retreated. A few have remained stationary and only two have made an advance. A number of glaciers in the Altai and Muss-tau mountains, in Siberia, have been visited but no careful measurements made.[4]

REPORT ON THE GLACIERS IN THE UNITED STATES FOR 1910[5]

There are a number of small glaciers in Colorado which, on the whole, show a tendency to become smaller, but their variations from year to year are extremely slight.[6]

The Hallett Glacier shows no measurable change since 1909 (Mills).

The Carbon Glacier on the northern side of Mt. Rainier is in marked recession (Matthes).

The United States Geological Survey has been continuing its explorations and surveys of Alaska, and several glacier regions have been mapped. A number of glaciers north of Juneau are in rapid recession. The glaciers in the neighborhood and north of the headwaters of the Copper River (in the neighborhood of latitude $63\frac{1}{2}°$ N and longitude 145° W) seem to be retreating slowly (Brooks).

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[1] Report of M. Rabot.

[2] Report of Professor Hamburg.

[3] Report of M. Oyen.

[4] Report of Colonel Schokalsky.

[5] A synopsis of this report will appear in the *Sixteenth Annual Report* of the International Committee. The report on the glaciers of the United States for the year 1909 was given in this Journal (XIX, 83–89).

[6] All available information regarding these glaciers has been collected by Judge Junius Henderson, "Extinct and Existing Glaciers of Colorado," *University of Colorado Studies* (1910), VIII, 33–76.

Fresh moraine, extending for nearly two miles at the end of Nabesna Glacier, shows that it is retreating rather rapidly. The Chisana Glacier, 15 miles to the east, has a very clean end; a comparison of photographs taken in 1899 and 1908 shows surprisingly little change in the aspect of the glacier, though at one place a slight recession has taken place. Frederika Glacier, entering White River valley from the north, when seen by Dr. C. W. Hayes in 1891 ended "in a nearly vertical ice cliff . . . . about 250 feet high. At the foot of the cliff there is a small accumulation of gravel and ice fragments apparently being pushed along by the advancing mass."[1] In 1909 Mr. Stephen R. Capps says "its surface is remarkably smooth and slopes down evenly to a thin edge in front." The Frederika Glacier has evidently changed from an advancing to a retreating glacier in the interval. Exactly opposite Frederika Glacier another glacier, in retreat in 1891, is now advancing.[2]

Such spasmodic cases are probably produced by sudden accession of material due to avalanches or land slides, rather than to simple variations in snow-fall or temperature.

The Ruth Glacier, rising on Mt. McKinley and extending many miles to the east, is slowly diminishing in size (Rusk).

Professor U. S. Grant and Mr. D. F. Higgins have published a general map of Prince William Sound, showing the location of all the glaciers, on a scale of 4 inches to the mile.[3] They have also published descriptions, pictures, and detailed maps of the ends of several of these glaciers.[4] The last observations were made in the summer of 1909 and we note that the Shoup Glacier was practically stationary and was fully as large then as it had been for several decades. The Columbia Glacier was found, at its eastern edge, about 500 feet in advance of its position of 1899, and this advance seems to have taken place principally since the summer of 1908. Professor Grant found indications that the glacier was well in advance some fifty years ago and before that date was considerably smaller. The Meares Glacier seems to be a little in advance of its position of 1905, and the general condition of the vegetation in the immediate neighborhood indicated that the glacier in 1909 was probably as far forward as it has been during the last one hundred years or more.

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[1] "Expedition through the Yukon District," *Nat. Geog. Mag.* (1892), IV, 153.

[2] "Glaciation on the North Side of the Wrangell Mountains, Alaska," *Jour. Geol.* (1910), XVIII, 56.

[3] "Reconnaissance of the Geology and Mineral Resources of Prince William Sound, Alaska," *U.S. Geological Survey, Bulletin No. 443,* Washington, 1910.

[4] "Glaciers of Prince William Sound and the Southern Part of the Kenai Peninsula, Alaska," *Bull. Amer. Geog. Soc.* (1910), XLII, 721–33.

Professor Lawrence Martin conducted another expedition for the National Geographic Society in 1910 to study the Alaskan glaciers. He sends me the following notes:

> *Fairweather Range.*—La Perouse Glacier advanced approximately a quarter mile between September 4, 1909, and June 10, 1910, and was destroying forest on the latter date, as it had previously done in September, 1895.
>
> *Yakutat Bay.*—Nunatak Glacier advanced 700 to 1,000 feet between July 6, 1909, and June 17, 1910, after retreating steadily at least 2½ miles from 1890 to 1909. Hubbard Glacier did not continue to advance as rapidly as seemed possibly would be the case in 1909, parts of the front advancing 600 feet between 1909 and 1910 while other parts retreated 500 to 1,000 feet. In 1910 Lucia Glacier had probably nearly ceased the great advance which was in progress in July, 1909. Nunatak Glacier is the ninth ice tongue in the Yakutat Bay region to advance since 1899, following a long period of continuous retreat or stagnation. In each case listed below the advance is thought to be the result of great accessions of snow and ice by avalanches during the earthquakes of September, 1899.

Glacier	Date of Advance	Length of Glacier
Galiano*	After 1895 and before 1905	2 or 3 miles
Unnamed Glacier	1901	3 or 4 miles
Haenke	1905–6	6 or 7 miles
Atrevida	1905–6	8 miles
Variegated	1905–6	10 miles
Marvine	1905–6	10 miles†
Hidden	1906 or 1907	16 or 17 miles
Lucia	1909	17 or 18 miles
Nunatak	1910	20 miles

* Between Haenke and Hubbard glaciers.

† Excluding expanded lobe in Malaspina.

Prince William Sound.—Columbia Glacier advanced 600 feet between August 24, 1909, and July 4, 1910, and at least 132 feet more between the latter date and September 5, 1910. In College Fiord the Harvard, Yale, Radcliffe, Smith, Bryn Mawr, Vassar, Wellesley, and Barnard glaciers were advancing much more actively in 1910 than in 1909, and were destroying forest at their borders, as were the Meares Glacier in Unakwik Inlet, the Harriman, Baker, Roaring, and Cataract glaciers in Harriman Fiord, and the Blackstone Glacier in Blackstone Bay. Harvard glacier had advanced 100 to 150 feet, Yale 750 feet, and Harriman 300 feet between 1899 and 1910. Barry and Surprise glaciers in Harriman Fiord retreated 2½ and 1¼ miles respectively from 1899 to 1910, different parts of the Barry retreating 500 to 1,600 feet of this distance between 1909 and 1910. Valdez and Shoup glaciers in eastern Prince William Sound and Nellie Juan Glacier in Port Nellie Juan remained unchanged from 1908 to 1910, as did Chenega, Princeton, and Tiger glaciers in Icy Bay, where there was a six or seven mile retreat between 1787 and 1908, most of it later than 1898. Portage Glacier in Passage Canal had a great advance between 1794 and 1880, filling a pass from Prince William Sound to Cook Inlet to a height of over 1,000 feet, where there was previously a low canoe portage and no glacier.

Copper River.—Miles Glacier retreated about 1,700 feet from 1900 to 1906 and readvanced 1,800 feet from 1906 to 1910. Grinnell Glacier advanced slightly between 1909 and 1910. Different parts of the front of Childs Glacier advanced 920 to 1,225 feet between 1909 and June, 1910, in midglacier, where the front is undercut by Copper River. On the north bank of the river where the margin of the glacier ends on the land and was stagnant in 1909, it advanced 1,500 to 1,600 feet up to June 10, 1910, and 204 feet more up to October 5, 1910. The glacier front developed lobes so that some parts advanced faster than others. The rates per day through the summer of 1910 were as follows:

Dates	Days	Advance in Meters		Rate per Day in Feet	
		Fastest	Average	Fastest	Average
June 10 to July 29	49	124	116	2.5	2.37
July 29 to Aug. 6	8	26	23	3.25	2.87
Aug. 6 to Aug. 11	5	41	8	8.2	1.60
Aug. 11 to Aug. 17	6	27	4	4.5	0.66
Aug. 17 to Aug. 29	12	42	19	3.5	1.58
Aug. 29 to Sept. 19	21	37	27	1.76	1.28
Sept. 19 to Oct. 5	17	13	7½	0.7	0.44

In midglacier there was a relative retreat of the advancing ice front from June to September, while the north border continued to advance strongly, as shown above. This retreat was due to undercuttings during the summer rise of the river and was followed by a strong advance in late September and early October when the level of the river fell and its undercutting power was weakened. This oscillation is shown in the accompanying table.

Dates	Variation of Glacier	Stage of River
1909 to June 10, 1910.......	Advance, 920–1,225 ft.	Fall, 14 ft., May 6 to June 10
June 10 to Aug. 11.........	Retreat, 450 ft.	Rise, 6 ft.
Aug. 11 to Aug. 17.........	Retreat, 65 ft.	Level, about stationary
Aug. 17 to ———..........	Retreat continued.......	Rise, 1 7/10 ft.
——— to Oct. 5...........	Advance, 390 ft., plus unknown retreat above	Fall, 9 ft.

As this advance of Childs Glacier seriously threatened a $1,400,000 steel railway bridge which in October, 1910, was only 1,575 feet from the north margin of the glacier, the behavior of Childs Glacier during the winter of 1910–11, when Copper River is low and weak, will be of much interest. The diminution of movement on the north bank suggests, however, that the advance is practically over. The advance of Grinnell Glacier is also of interest, for this ice tongue occupies a strategic position with reference to the railway, which traverses its stagnant outer portion. In this portion, however, there was no disturbance in 1910, the advance affecting another part of the glacier. The Allen Glacier, whose stagnant outer portion is traversed for 5½ miles by this railway, remained unchanged from 1909 to 1910.

It appears, therefore, that the glaciers about Prince William Sound give some indication of a general, but not very large, advance.

CORRECTION.—In the Report on the Glaciers of the United States for 1908 (*Journal of Geology*, XVII, 671), the name "Matamaka Glacier" should have been "Matanuska Glacier."

The regular meeting of the International Committee on Glaciers took place in Stockholm on the 20th of August, 1910, in connection with the Eleventh International Geological Congress.[1] The retiring president, Professor Edouard Brückner, presented the report of the Committee to the Congress.

He called attention to the origin of the Committee, which was first appointed by the Sixth International Geological Congress in 1894, and has been collecting information regarding the variations of glaciers ever since; and emphasized the importance of the work of Professor Finsterwalder, who, as retiring president in 1903, laid down the fundamentals of a mathematical theory of glacier variations. He then reviewed the information collected regarding the variations of glaciers. In the Alps the retreat of the glaciers continues steadily, although a few glaciers of the Oetztal and some others have made small temporary advances. The retreat has lasted for several decades. A graphic representation of the variations of 26 glaciers in the Swiss Alps, including the Mont Blanc group, shows that, for the greater number of them, the retreat has lasted since the beginning of the nineteenth century, and that the advance which occurred about 1850 was but an episode in the general retreat. Since that time the retreat has been still more marked. In the Scandinavian Alps the variations have been somewhat different; in this region an advance occurred in the beginning of the twentieth century. It began in the Jostedalsbrä and the Folgefon and progressed toward the north; but the advance was confined to the coast region and the glaciers in the mountains of central Scandinavia did not participate in it. This advance must also be looked upon as an unimportant event in the general retreat. The glaciers of the Caucasus, of the Tyan-Shan, the Altai, the Highlands of Pamir, and the Himalaya are in retreat, though here also special cases of advance have been noted. Among the glaciers of the United States and Canada the retreat is general and this is true to a still more marked extent in Alaska. Between 1892 and 1907, the retreat of the glaciers has increased the area of Glacier Bay by 19 square miles. Of great interest are the sudden remarkable advances of the glaciers of Yakutat Bay, which Professor R. S. Tarr has described and imputed to the great increase in snow-supply due to avalanches incited by the earthquakes of 1899. Professor Hauthal has described the rapid advance of the Bismarck Glacier, in South America, since the end of the last century.

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[1] "La Commission internationale des Glaciers au Congrès géologique international, Stockholm, août, 1910." *Zeitschrift für Gletscherkunde* (1911), V, pp. 161–76.

Professor Kilian described the variations of glaciers in France. The importance of the water from glacial streams has led the Minister of Agriculture to give material aid to the observations of glaciers.

Professor Dr. F. W. Svenonius spoke of the difficulty of making observations among the Swedish glaciers on account of their distance and inaccessibility, but nevertheless the Swedish Geological Survey has published a collection of six essays by the leading Swedish glacialists which give an excellent account of what is known of these glaciers.[1]

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[1] Dr. Axel Hamberg has been elected an ordinary member of the Committee to represent Sweden, succeeding Dr. F. W. Svenonius, who has retired and been elected a corresponding member. Professor R. S. Tarr has also been elected a corresponding member. Two corresponding members, Mr. W. S. Vaux, Jr., and Professor E. Hagenbach-Bischoff, have died since the 1906 meeting of the Committee. The following officers were elected to serve until the next meeting of the International Congress of Geologists: Honorary President, Prince Roland Bonaparte of Paris; Active President, M. Charles Rabot of Paris; Secretary, M. Ernest Muret of Lausanne.